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5. SAFETY ENVELOPE

The *Safety Envelope* is a set of physical and administrative conditions that establish and define the boundaries within which the facility can be safely operated. Variations beyond the boundaries of the Safety Envelope are reportable occurrences.

The requirements in the Safety Envelope follow from the safety analysis in Chapter 4 but focus principally on ionizing radiation, the hazard that distinguishes accelerator facilities from other heavy laboratory operations. Otherwise, it is assumed that existing Los Alamos safety management activities makes a detailed envelope definition unnecessary for most aspects of LANSCE operation.

A significant change to the Safety Envelope requires acceptance through the SAD revision (or supplement or update) process. If a proposed activity would result in a significant increase in risk, it is handled as through the Unreviewed Safety Issue Determination (USID) process[1] until accepted as an SAD revision.

Facility operations routinely take place with variability in many parameters. To provide a margin inside the Safety Envelope, an envelope of Operational Limits defines the boundary conditions for allowable operation. With rare exceptions, the facility operates entirely within the Operational Limits, and unplanned excursions are cause for internal investigations to evaluate possible Safety Envelope violations. The Operational Limits reflect written internal policies and procedures such as the AOT-6 (Accelerator Operations Group) Operations Manual (OpMan) and the TA-53 Prompt Radiation Protection Policy[2] (PRPP) that can be changed by the respon0sible organizations at LANSCE through a formal process.

Normal operations take place within a still more restrictive set of conditions. LANSCE beam operation uses a Normal Operations Envelope listing best practices for routine operation. Excursions outside the Normal Operating Envelope but inside the Operational Limits can be authorized routinely or are subject to routine review within the affected LANSCE operating group/s.

5.1 IONIZING RADIATION

Table 5-1 specifies technical controls for safe management of the hazard of ionizing radiation from all sources at all times and also specifies additional controls for prompt radiation during beam delivery and for radioactive materials management. The table rows are numbered for referenced in the subsequent discussion. Following this, administrative controls are described.

Table 5-1. Ionizing Radiation Safety Envelope.
Conditions for Normal Operations include the Operational Limits and the Safety Envelope.

	Normal Operations		
	Operational Limits		
Parameter	**Safety Envelope**		
Radiation Control–General			
1. Shielding and exclusion barriers	In place*		In place for ALARA purposes
2. High Radiation Area Access Control >1 rem	Functional*	No unauthorized entry	Following provisions in RPP*
3. Very High Rad. Area Access Control	Functional*	No entry	
Prompt Radiation Control			
4. Shielding and exclusion barriers		In place as required by PRPP	
5. Radiation Security System	Access control interlocks functional* thru at least one chain	RSS functional thru both chains	All intended elements functional
6. Other interlocks		Run Permit (RP) functional	Fast Protect functional, equipment within tolerances
7. Required equipment testing	On access control interlocks after modifications, maintenance, & annually*	RSS and other interlocks checked per OpMan	Equipment readiness checks
8. Max. beam, μA Line A		1500	1000
Line D		150/250*	100/200*
Line X		10	5
WNR		30	5
Radioactive Materials			
9. Production & handling	With containment and procedures*		
10. Radioactive air exhaust	[LANL limit ≤10 mR at site boundary]	Monitoring sys. functional; LANSCE within LANL budget.	Operational air exhaust system

*See text

5.1.1 Safety Envelope

5.1.1.1 Radiation Controls–General

The requirements for exclusion barriers, shielding, and access controls are somewhat interdependent. The minimum radiation containment system could be a means to define the perimeter of a hot area. Above 1 rem/h, the means should be an exclusion barrier. Frequently, shielding is employed to reduce the size of the area, and is often part of the exclusion barrier. There is no separate Safety Envelope requirement for shielding per se; shielding allows use of smaller radiological areas, helps ALARA dose reduction, and

otherwise reduces risk. Access controls can be used to allow area entries under some conditions.

1. Exclusion barriers and shielding shall be in place so that (Very) High Radiation Areas are well-defined and access is practical only through designated entry points. This condition would be violated for example if an area were found with a radiation field of 2 rem lasting for an hour or more without the required access controls per 835.502. Verification of the shielding and barrier integrity is provided by routine inspections, radiation surveys, and dosimetry; and electronic instrumentation during beam operation.

2–3. Access controls shall be functional for (Very) High Radiation Areas above 1 rem/h. “Functional” means capable of preventing inadvertent entry while the hazard is present. Entryways supervised or locked, in either case with accountable management controlling access, satisfies this condition. Access to HRAs is allowed under some conditions. Access to VHRAs is not allowed. A VHRA without the means to exclude access, whether by failure to control entryways or failure to have a complete barrier, would be a violation of the Safety Envelope.

In judging whether a situation presents a possible violation of the Safety Envelope, the emphasis should be on whether inadvertent exposure of a person to a whole body dose of 1 rem equivalent in 1 hour is a practical possibility. Discovery of a limited-volume “hot spot,” or a hot area in a practically inaccessible location, would not be considered a violation of the envelope. A momentary high radiation level would not be considered a violation. Entry of an RCT into an area of unknown radiation level in order to measure the level is not a violation of this part of the envelope. Exclusion barriers and access controls are intended to prevent inadvertent entry; it would not be a violation of the Safety Envelope if a barrier was intentionally defeated by a person using tools or climbing up or down a barrier over 6’ high. Inadvertent presence of a person in an area that changes to a high radiation area might be a Safety Envelope violation if the failure was the result of equipment or procedural failure. Posting can be an element of access control used temporarily during changing conditions, for example a rope barrier with “Very High Radiation—No Entry” signs can be used during the workday while more substantial barriers are being put in place. When the work requires removal of barriers, direct supervision of access is considered adequate control.

5.1.1.2 Prompt Radiation Control

These conditions apply to an area when the accelerator is powered and capable of delivering beam to or near the area. These conditions do not apply where configuration locks or configuration-controlled facility modifications prevent beam delivery or prompt

radiation from reaching an area, or prevent occupancy of an area. These conditions add to the requirements in "Radiation Controls–General." Table 4-4, which shows the possible combinations of radiation hazards and access circumstances, may be useful in understanding which control measures variously apply.

4. Shielding and exclusion barriers: no additional Safety Envelope conditions.

5. The access control interlocks shall be functional when beam is on or ready. The access control interlocks consist of the doorway release device and indicators, the devices that prevent beam passage, and their interconnection. The interlocks prevent simultaneous personnel access and beam delivery to an area. The interlock condition is satisfied for a given area during beam operation if at the minimum a single interlock chain keeps beam out of each area with an open entryway. This condition is a required entry in the Safety Envelope by DOE and LANL orders and standards for access controls such as DOE 5480.25 section 9.c.1. If beam is on to an area, or could be turned on by the normal controls, while a person could walk into the area through an entryway, then the interlocks are not functional. The OpMan provides procedures and schedules for verifying functionality.

6. Other interlocks: no Safety Envelope conditions.

7. The access control interlocks to an area shall be checked prior to beam delivery to the area under any of the following circumstances:

• after modifications or maintenance,
• if interlock configuration control as described in the OpMan was not continuously maintained, or
• if a check has not been made in the last year.

The Accelerator Operations Group maintains records of interlock checkouts, operational modifications, and bypasses.

5.1.1.3 Radioactive Materials

9. Generation of radioactive materials as a product or byproduct in primary beam targets enclosed by shielding is included in the Safety Envelope. The analysis in Section 4.4.5.1 shows that while enclosed, the safety risk from release is very small. Transfer of irradiated solid materials into Laboratory-approved containers following approved procedures is also within this Safety Envelope. Transportation and processing of such materials is covered by other Laboratory procedures and is not considered here. Experimental use of radioactive materials is subject to the experiment safety analysis process (Section 5.2).

[10. LANSCE radioactive air emissions are managed by LANSCE and LANL to be in compliance with EPA agreements. This is not in the LANSCE Safety Envelope but is a similar item and is mentioned here for completeness.]

5.1.1.4 Administrative Controls

5.1.1.4.1 Radiological Protection Program

LANSCE shall participate in the LANL Radiological Protection Program (RPP; currently LM107-01, but under revision as "Radiological Protection Program Standards[3]"). Elements of this program in addition to the technical features above include worker dose management, radiological hazard communication including posting, and radiological materials management.

Personnel exposures shall be monitored by an accredited dosimetry program so that worker doses can be managed during the year. Operation of a dosimetry program accredited per 10 CFR 835 is a required element of the Safety Envelope. The LANL dosimetry program, which includes both external and internal monitoring, is described in detail in Section 3.3.3. The Radiation Protection group (ESH-1) is responsible for providing the measurements. Worker line supervision is responsible for dose management. Deficiencies in monitoring practices that do not significantly affect dose management or do not show disregard by the institution are not considered a violation of this requirement. Depending on circumstances, if a worker deliberately avoided recording a significant dose (>100 mrem) in a week of work, it might be handled as a disciplinary action instead of a Safety Envelope violation. Tolerance of this practice by supervision would be a violation.

Radiological areas shall be posted per 835.603 sufficiently for hazard communication purposes. Posting is principally a means of hazard communication rather than dose management, since procedures and systems are used to minimize personnel exposure. Posting errors without significant likely consequences are not considered a violation of the Safety Envelope provided they are promptly corrected or are not likely to lead to significant exposure. Failure of the illuminated signs that automatically indicate the status of beam delivery areas is not considered a violation of the Safety Envelope, because the access system prevents personnel exposure, and its status provides equivalent information (area locked up means high radiation inside). Failure to promptly post an area that is likely to be occupied with a general and sustained level of 200 mrem for an hour as a High Radiation Area would be a violation of the Safety Envelope. Radiological posting and routine montoring is the responsibility of the Radiation Protection group.

The ALARA radiation protection policy is described in Section 3.3.3.3.

Materials released from radiological areas shall be monitored to be within the activation limits of 835.1101. As part of standing routine, materials leaving radiological areas are monitored manually by RCTs and in some cases automatically by portal monitors, and records of the release are kept. Occasionally, equipment might be released on-site slightly exceeding allowable thresholds but then subsequently identified, for example, when checked by a different measurement device. When there have been no significant consequences, this envelope condition is intended to cause the operation in question to be reviewed rather than causing a general halt to operations.

5.1.1.4.2 Configuration Control

Configuration controls shall be kept on safety-related equipment such as shielding, barriers, and the access control locks and interlocks. This item is a required entry in the Safety Envelope by DOE and LANL regulations for configuration control and formality of operations (example: 5480.25 section 9.a.2).

At the Safety Envelope level, configuration control of the barriers and shielding is maintained by the area support groups as described in Section 3.3.1.3.1. Prior to significant disassembly, the area support group or the Accelerator Operating Group locks in a beam inhibiting device (or makes an exclusion area), and after reassembly and inspection, unlocks the device (or opens the area). Records are kept of these steps. During beam operation, the management of the area support group is responsible for maintaining the barriers and shielding in an adequate condition, and for judging what conditions or when modifications require the beam to be locked off.

The configuration of RSS/PACS/PSS/IPSS equipment is controlled by means of testing and inspection as described in the OpMan.

Section 5.4.1 describes the RSS formal configuration control program.

5.1.2 Operational Limits Envelope

The Operational Limits list those conditions beyond which the facility does not intentionally operate, except rarely under special and carefully controlled circumstances. Unlike the Safety Envelope, authorization to exceed an Operational Limit can be granted by responsible line management. The Operational Limits have a large margin inside the Safety Envelope.

5.1.2.1 Physical controls

1. Shielding and exclusion barriers: no additional general conditions.

2–3. Operational Limits include no incidents of unauthorized entry into High Radiation Areas, and no entry into Very High Radiation Areas. An unallowed entry made by willful

violation of access controls would be a serious and reportable occurrence and a violation of the Operational Limits, but not necessarily a violation of the Safety Envelope.

4. Operational Limits include having shielding and exclusion barriers in place during beam operation per the TA-53 Prompt Radiation Protection Policy. This requirement can result in placement of barriers and access control systems in normally low radiation areas to reduce risk potential from errant beams. Shielding and barrier placement is the responsibility of the area support groups and is confirmed by LANSCE readiness reviews prior to major operating periods if a review has not occurred in the last year. Records maintained by the Accelerator Operations Group indicate completion of these steps. During operating periods, any change that significantly reduces shielding or exclusion area boundaries should follow a configuration control process.

5. Operational Limits include includes having two RSS interlock chains functional (where redundant chains are installed); that is, either chain is able to meet the purposes of the system independently of the other. The system could have several failed elements in various locations and still be functional and redundant.

In addition to the access control interlocks (PACS/PSS/IPSS, included in RSS) this requirement includes RSS instrumentation capable of preventing health-theatening levels in occupiable areas under extreme errant beam conditions. Sufficient redundancy is provided within the system that loss of any one element or leg does not compromise this capability. The “functional” condition would be violated if a prompt radiation level of 25 rem could be sustained for an hour in an area without High Radiation access controls. (The instrumentation generally enforces a level below 1 rem/h, but this is difficult to establish conclusively everywhere.) This requirement, like the preceding one (4), is for prudent risk reduction but is not in the safety envelope because Table 4-6 shows that errant beam conditions this extreme are not expected to occur in the lifetime of the facility, so this Operational Limit does not appear in the Safety Envelope. Personnel dosimetry, fixed dosimetry, routine monitoring, and accelerator and radiation instrumentation provide a record of significant radiation excursions. The Accelerator Operations Group verifies functionality on a schedule set in the Operations Manual and maintains records of checkouts, operational modifications, and bypasses.

6. Operational Limits include a functioning Run Permit (equipment line-up) interlock chain. This condition ensures that beam is directed only towards areas ready for beam. Sustained delivery of beam to an unready destination would be a violation of this condition. A momentary incidence terminated automatically by the system would not be considered a violation (this is one respect in which the Operational Limits differ from the Safety

Envelope regarding beam delivery to an open area). Within the Operational Limits, administrative procedures allow for bypassing parts of Run Permit.

This condition includes functionality of interlocks for equipment protection, such as cooling for beam targets. This condition is not in the Safety Envelope because the Safety Analysis shows that melted material would be adequately confined. Redundant interlocks maintain functionality in most of the system when some elements are out of service. The Equipment Readiness Checkouts by the area support groups provides periodic verification of functionality. The Accelerator Operations Group maintains records of checkout, failures, and bypasses.

7. Operational Limits include interlock checks as specified in the OpMan.

8. Operational Limits include beam current limits. Two levels are indicated for the Line D areas. The higher limit applies after facility modifications are completed to enable higher beam currents to the PSR and MLNSC, the lower limit applies until then. Beam current limits are in the Limiting Operations Envelope because the electronic beam current limiting system provides positive and automatic control of beam operating power, vital operating parameters. Beam current limits are not in the Safety Envelope because the analysis shows that there is no direct or likely safety consequence to exceeding beam current limits; several other safety factors must be concurrently violated in order for consequences to be significant. The Line D and Line X beam current limits in the Operational Limits are the limiter system set points plus a tolerance. The limiters are tested on a schedule set by the Accelerator Operations Group.

9. Production & handling of radioactive materials: no further condition.

10. Operational Limits include operation of the air exhaust system as intended to meet ALARA goals and other air emissions requirements. Facility operation will be managed so that the LANSCE stays within its annual emissions budget agreed to by LANL, currently 8.5 mrem/year maximum at the site boundary. The responsibility lies with TA-53 facility management and operating/support groups, with support from ESH-17.

5.1.2.2 Administrative Controls

Operational Limits include the LANL and DOE administrative guideline of less than 2 rem per year total individual radiation dose to a Radiation Worker.

Operational Limits include staffing for accelerator operations (control room staffing) with persons as directed by line management in the Accelerator Operations Group and above. Since the control system safety features for beam delivery are automated, this requirement is not found in the Safety Envelope.

Operational Limits include equipment testing, checkout, and configuration control as specified in the OpMan and by the procedures of support organizations such as Radiation Protection. This covers additional equipment and systems such as Run Permit not included in the Safety Envelope. This also covers checkout and monitoring of barriers and shielding by routine inspections and radiation surveys, records from personnel and fixed dosimeters, radiation instrumentation, and authoritative reviews of significant modifications. These measures are implemented by the area support groups, the Radiation Safety Committee, the LANSCE Operational Safety Committee, the Radiation Protection group, and the Facility Management Group. Records of these steps are kept. Section 3.3.1.3.1 describes the configuration control process for moveable shielding and barriers.

5.1.3 Normal Operations Envelope

5.1.3.1 Physical Controls

1. The Envelope for Normal Operations includes the use of shielding and barriers for ALARA purposes.

2. In High Radiation Areas, entry conditions follow the Radiological Protection Plan; e.g., work is done by a Rad Worker II following an RWP.

3. Very High Radiation Area access: no additional conditions.

4. Shielding and exclusion barriers: no additional conditions.

5. The Envelope for Normal Operations includes full functionality of all Radiation Security System (RSS) equipment intended to be in service. Modifications, response to failure, and records are handled as prescribed in the OpMan.

6. The Envelope for Normal Operations includes a functional Fast Protect system, and equipment running within tolerances. This is an ALARA-related requirement that helps minimize errant beam, unwanted radioactivation of the facility, and repair work to beam-damaged components. Within this envelope, administrative procedures allow for bypassing parts or all of FP. The Accelerator Operations Group maintains records of checkout, failures, and bypasses

7. Required equipment testing: equipment readiness checks should be done as specified in the OpMan.

8. The Envelope for Normal Operations includes the maximum scheduled beam current levels. These are typical target levels for production, and a small variation around the target levels is normal. Verification is possible by comparison of schedules and records kept by the Accelerator Operating Group.

9. Production & handling of radioactive materials: no further condition.

10. The Envelope for Normal Operations includes ensuring that the air exhaust system is fully operational, as needed for the various beam delivery areas and conditions.

5.1.3.2 Administrative Controls

The Envelope for Normal Operations includes ALARA dose reduction. To meet this goal, management tracks worker dose on an interval sufficient for ALARA planning purposes—quarterly, monthly, daily, or by the job, or otherwise as appropriate. The Envelope for Normal Operations includes detailed radiological postings to assist ALARA objectives. Typically, areas with ambient radiation above 10-20mrem/h are posted where occupancy is likely.

The Envelope for Normal Operations includes control room staffing with the number of qualified operators as specified in the OpMan. Since the control system safety features for beam delivery are automated, this requirement is not found in the Safety Envelope. The Envelope for Normal Operations includes routine documentation of operation including control room logs and records of non-safety-system interlock changes and bypasses.

The Envelope for Normal Operations includes monitoring of all equipment removed from radiological areas.

5.2 EXPERIMENT SAFETY ENVELOPE

Experiments and facilities at TA-53 are subject to the LANL ESH-ID process, which identifies hazards of activities and applicable regulatory and safety requirements. New experimental setups and facilities are also reviewed by TA-53 Facility Management according to “ES&H Review of Experimental Activities and Development Tests” (53 FMP 114-01) to ensure that hazards are adequately controlled and do not violate facility safety envelopes. Routine use of experimental facilities is monitored by the area support groups and local experiment review committees. An experiment that introduced significant hazards without controls acceptable to the facility (and Laboratory and DOE, depending on the specific safety issues) would cause a Safety Envelope violation. The Laboratory Administrative Requirements, Procedures and Standards[4] that help define allowable hazards and risks are available via the Web.

5.3 MANAGEMENT OF RADIOACTIVE MATERIALS

Any activity involving radioactive material inventories which could exceed a facility safety envelope or be outside the bounds of a facility hazard classification is treated through the Unreviewed Safety Issue Determination (USID) process per DOE 5480.25 and TA-53 standard 53FMS 114-02.

Radioactive sources are controlled in accordance with AR 3-4. Custodians for radioactive material must maintain secure storage and inventory listings and ensure that sources are periodically leak tested. All purchase requests for radioactive sources are sent to the Radiation Protection Group for review. Source inventories are periodically audited by the Radiation Protection Group. Items considered Nuclear Materials are subject to additional accountability and storage controls under the LANL Material Control and Accountability Plan.

5.4 CONTROL OF SAFETY SYSTEMS

5.4.1 RSS Equipment

The Radiation Security System (RSS) is an interlock system designed to protect facility personnel from prompt radiation hazards. The RSS is composed of personnel access control interlock systems, beam spill monitoring systems, beam current intensity limiting systems, radiation monitoring equipment necessary to limit personnel prompt radiation exposure, and supporting system logic and beam shutoff devices.

An RSS Quality Assurance Management Plan has been developed and documented to ensure that necessary procedures and standards are in place to provide confidence that the Radiation Security System will perform as intended. This plan was developed in accordance with the LANL Quality Assurance Management Plan and DOE Order 5700.6C. The requirements apply to all aspects of and work activities related to RSS. These include the design, installation, modification, component procurement, testing and operations of the RSS for the linac, beam delivery, and experimental areas.

A Radiation Security System Assessment of a beam delivery area is performed following a major maintenance period and beam delivery, if this has not been performed in the last year. The assessment standards include DOE 5480.25 Guidance, Part F, Beam Interlock Safety System; and the Los Alamos National Laboratory Standard, Accelerator Access Control Systems, LS107-01.

Recent system experience with trips, false alarms, failures, and bypasses is tracked to reduce weaknesses and improve system performance and reliability. These reports go to the accelerator division management and the operations safety oversight committees (LOSC, RSC).

New RSS installations and/or modifications to existing installations require review by the LANSCE Operations Safety Committee (LOSC). Members of this committee are chosen to provide expertise on the safe operation of the accelerator and beam delivery complex. Their recommendations are forwarded to the TA-53 Landlord for approval.

The Radiation Safety Committee (RSC) reviews the RSS implementation for conformance with the goals of the TA-53 Prompt Radiation Protection Policy.

Procedures ensure that the drawings, procedures, checklists, and other documents important to the integrity of the RSS are prepared, reviewed, approved, revised, and distributed with appropriate controls.

Procedures defined in the AOT-6 Operations Manual identify, report, document, correct, and trend the operational performance of the Radiation Security System. Procedures define inspection and testing requirements and ensure that inspection and testing activities are conducted and documented appropriately. Criteria of acceptability for inspections and tests are defined and documented. RSS systems are tested as prescribed in the OpMan, individual verification signatures are required for each step in the interlock check procedure, and the records are maintained for at least three years. Procedures in the AOT-6 Operations Manual also define the process and authorization required for bypassing RSS functions.

Access to RSS wiring and components is controlled by tamper-resistant features including special locks. Verification of lockout is required by interlock check procedures in the OpMan. Authorization by the RSS Engineer is required for access.

The position of RSS Engineer has been established to ensure that RSS compliance requirements are met with existing and new designs, maintenance is performed, quality issues are addressed, successful operation is verified and documented, and configuration control is maintained for the Radiation Security System.

Employees who design or maintain the Radiation Security System are qualified and trained as necessary to maintain the integrity of the RSS. If untrained personnel perform work on the RSS, qualified maintenance personnel certify the work prior to use of the affected portion of the system.

5.4.2 Other Safety Equipment

No safety requirements other than that itemized above is covered in the Ionizing Radiation Safety Envelope for LANSCE Operation. Conduct of other activities within Laboratory guidelines (see Table 4-1) is considered to provide acceptable risk management.

5.5 PERSONNEL TRAINING

The TA-53 Facility Manager provides facility-specific training at TA-53 as is described in Section 3.5.6.

LANSCE accelerator operators are qualified for their duties in accordance with DOE 5480.25 through an AOT-6 OJT (on-the-job training) program.

5.6 SUMMARY

This chapter gives the Safety Envelope for LANSCE operations. The Safety Envelope is detailed with regard to ionizing radiation safety, especially for prompt radiation, since this is an accelerator-specific hazard and is not common elsewhere in Los Alamos National Laboratory. A fundamental element in the prompt radiation Safety Envelope is personnel exclusion from beam delivery areas by means of barriers and access control systems.

The safety envelope is less detailed with regard to the other hazards which are bounded by extensive Laboratory policies.

5.7 REFERENCES

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[1] TA-53 Standard Determination of Unreviewed Safety Issues, 53FMS 114-02.01, prepared by C. John Graham, AOT-FM, available on http://www.atdiv.lanl.gov/ via the AOT-FM page.

[2] Prompt Radiation Protection (effective date 1/1/96), 53FMS 107-01.0, available on http://www.atdiv.lanl.gov/ via the AOT-FM page.

[3] Radiation Protection Program Standards, draft available via http://iosun.lanl.gov:2001/htmls/policy/lsp/lsp.html

[4] Los Alamos National Laboratory ES&H Program Documents, available via http://iosun.lanl.gov:2001/htmls/policy/esh/eshprgm.html